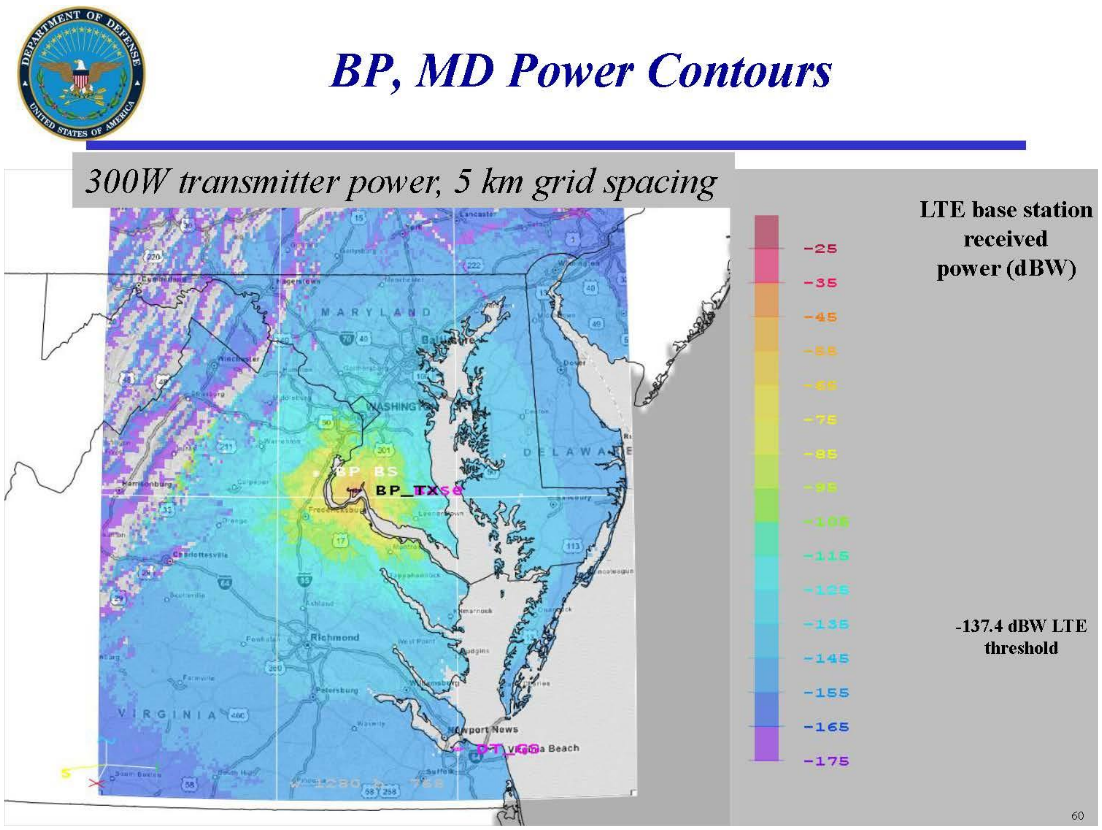
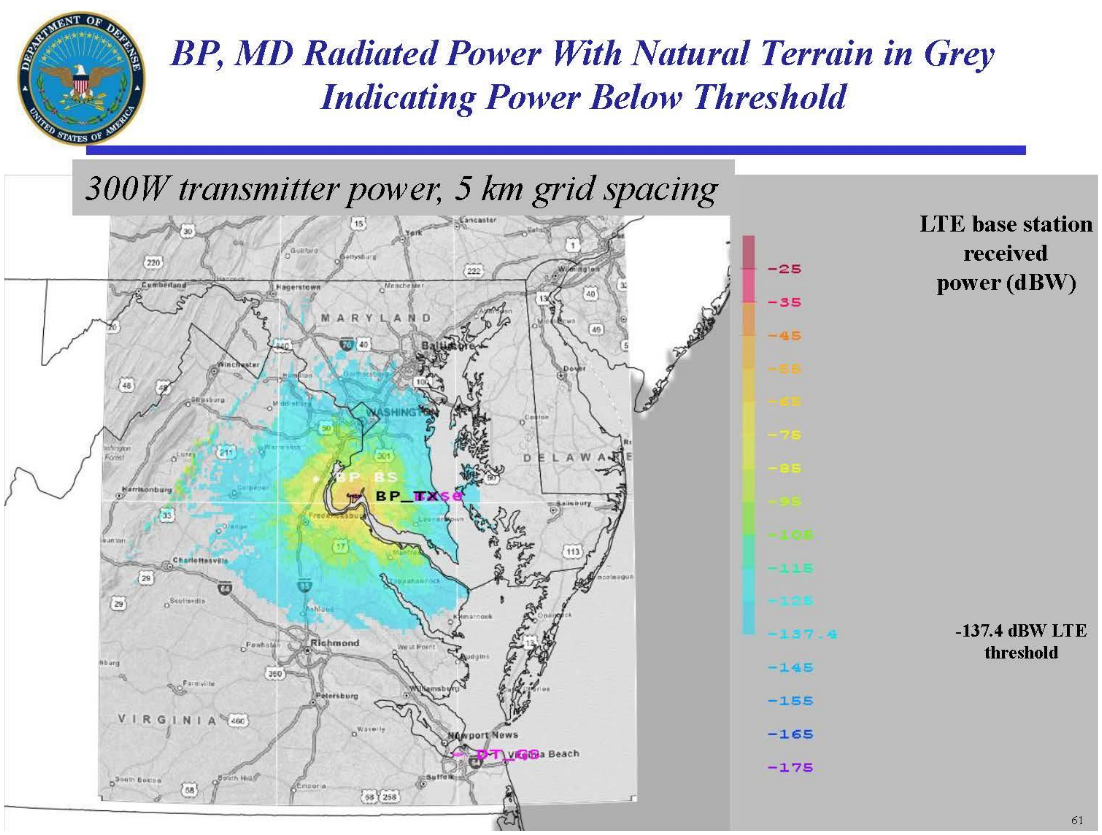
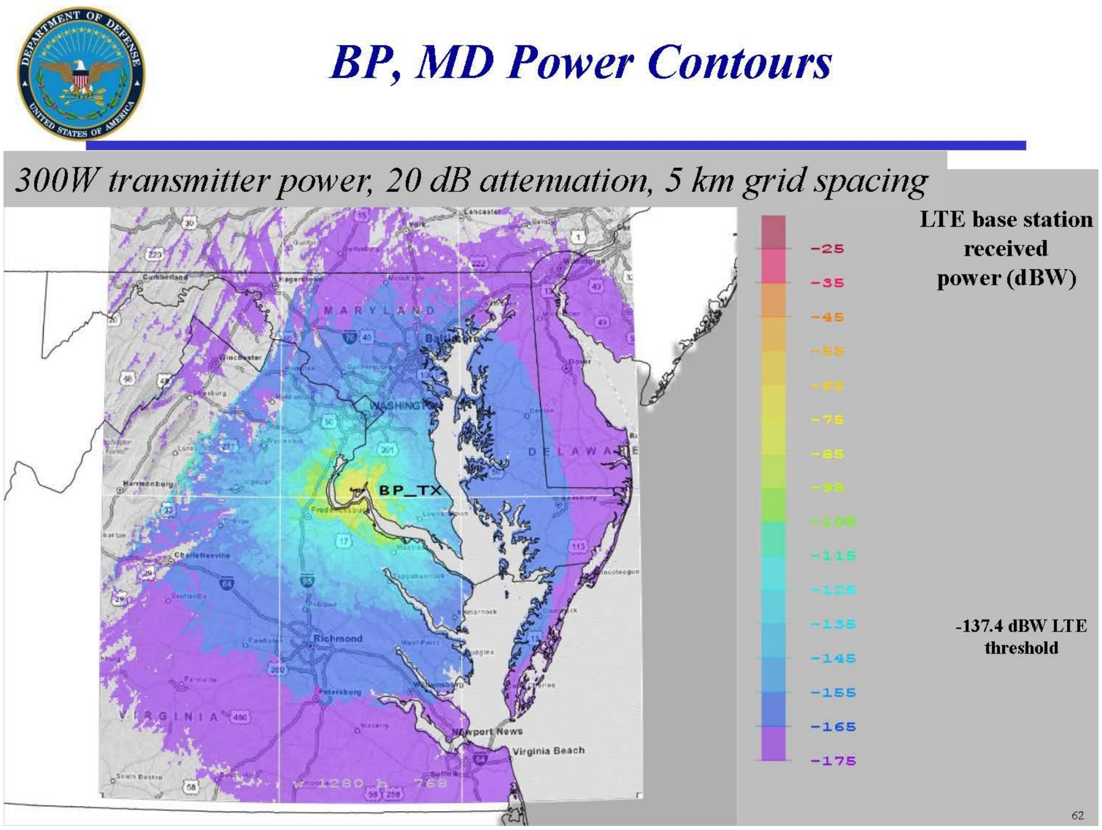
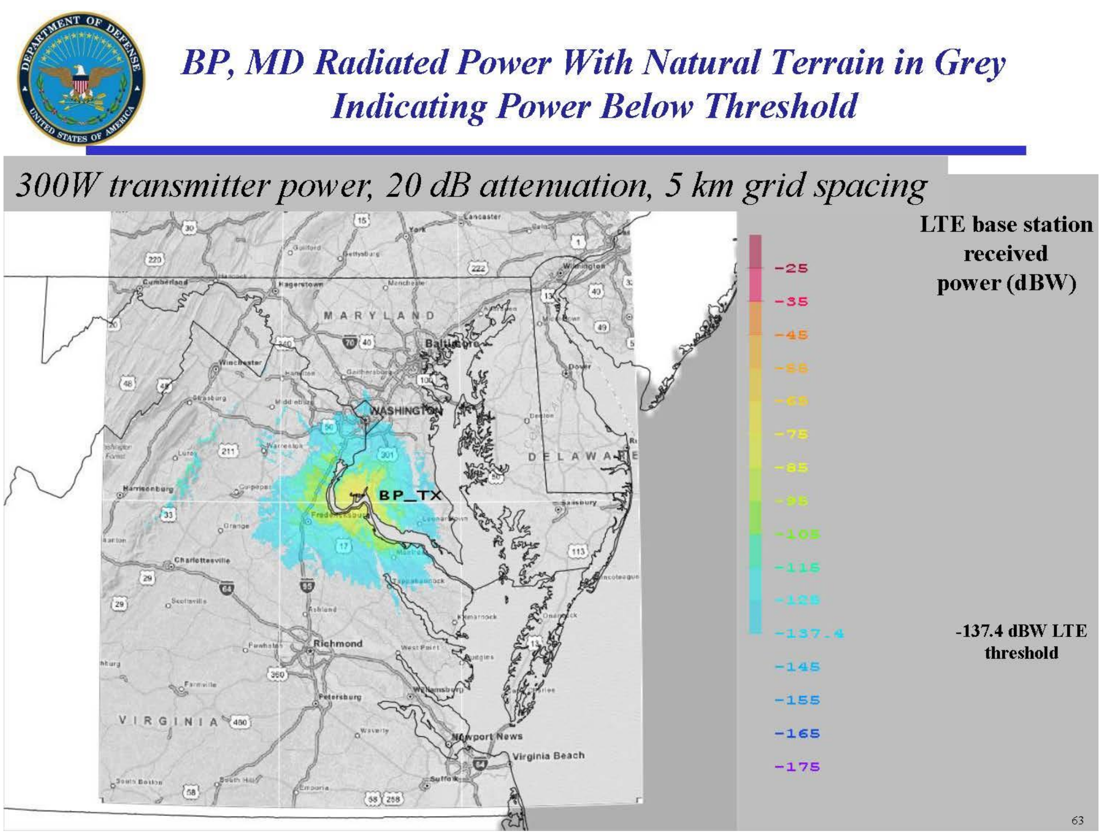

BP, MD Power Contours
300W transmitter power, 5 km grid spacing
LTE base station received power (dBW)
-25
-35
-45
-55
-65
-75
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
-137.4 dBW LTE threshold
MARYLAND
DELAWARE
VIRGINIA
WASHINGTON
Baltimore
Richmond
Newport News
BP_BS
BP_TX
60

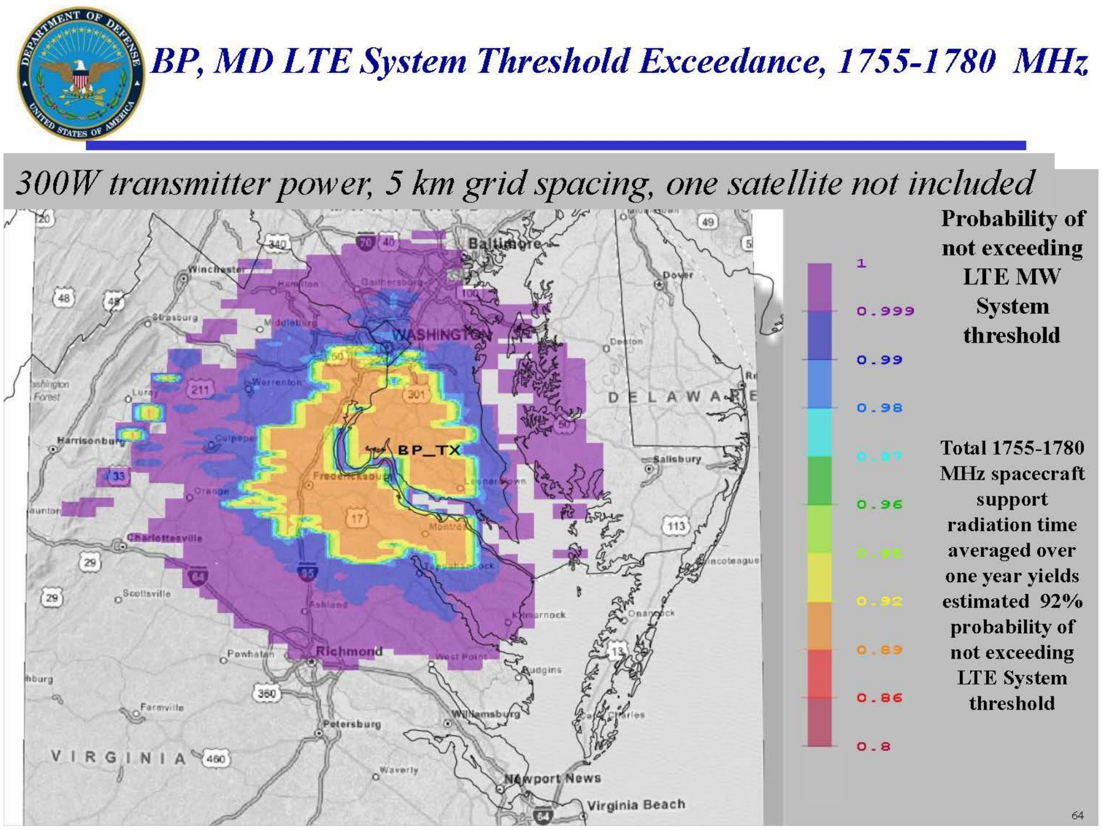
2268


BP, MD Radiated Power With Natural Terrain in Grey Indicating Power Below Threshold
300W transmitter power, 5 km grid spacing
LTE base station received power (dBW)
-25
-35
-45
-55
-65
-75
-85
-95
-105
-115
-125
-137.4
-145
-155
-165
-175
-137.4 dBW LTE threshold
MARYLAND
DELAWARE
VIRGINIA
WASHINGTON
Baltimore
Richmond
Newport News
BP_BS
BP_TX
61

2269

2270

BP, MD Power Contours
300W transmitter power, 20 dB attenuation, 5 km grid spacing
LTE base station received power (dBW)
-25
-35
-45
-55
-65
-75
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
-137.4 dBW LTE threshold
MARYLAND
DELAWARE
VIRGINIA
WASHINGTON
Baltimore
BP_TX
Richmond
Newport News
Virginia Beach
62

2271

BP, MD Radiated Power With Natural Terrain in Grey Indicating Power Below Threshold
300W transmitter power, 20 dB attenuation, 5 km grid spacing
LTE base station received power (dBW)
-25
-35
-45
-55
-65
-75
-85
-95
-105
-115
-125
-137.4
-145
-155
-165
-175
-137.4 dBW LTE threshold
MARYLAND
DELAWARE
VIRGINIA
WASHINGTON
Baltimore
BP_TX
Richmond
Newport News
Virginia Beach
63


BP, MD LTE System Threshold Exceedance, 1755-1780 MHz
300W transmitter power, 5 km grid spacing, one satellite not included
Probability of not exceeding LTE MW System threshold
1
0.999
0.99
0.98
0.96
0.92
0.89
0.86
0.8
Total 1755-1780 MHz spacecraft support radiation time averaged over one year yields estimated 92% probability of not exceeding LTE System threshold
BP_TX
Baltimore
WASHINGTON
Fredericksburg
Richmond
Charlottesville
Harrisonburg
Salisbury
Petersburg
Williamsburg
Newport News
Virginia Beach
VIRGINIA
DELAWARE
64

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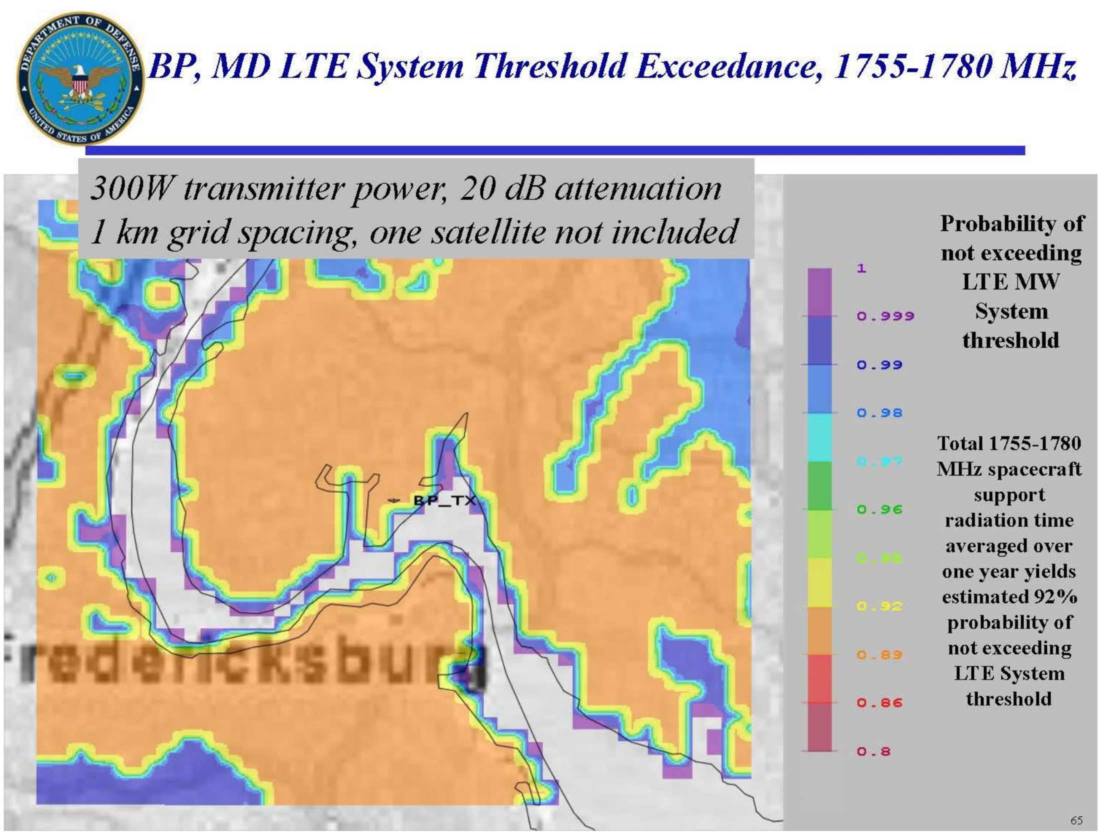
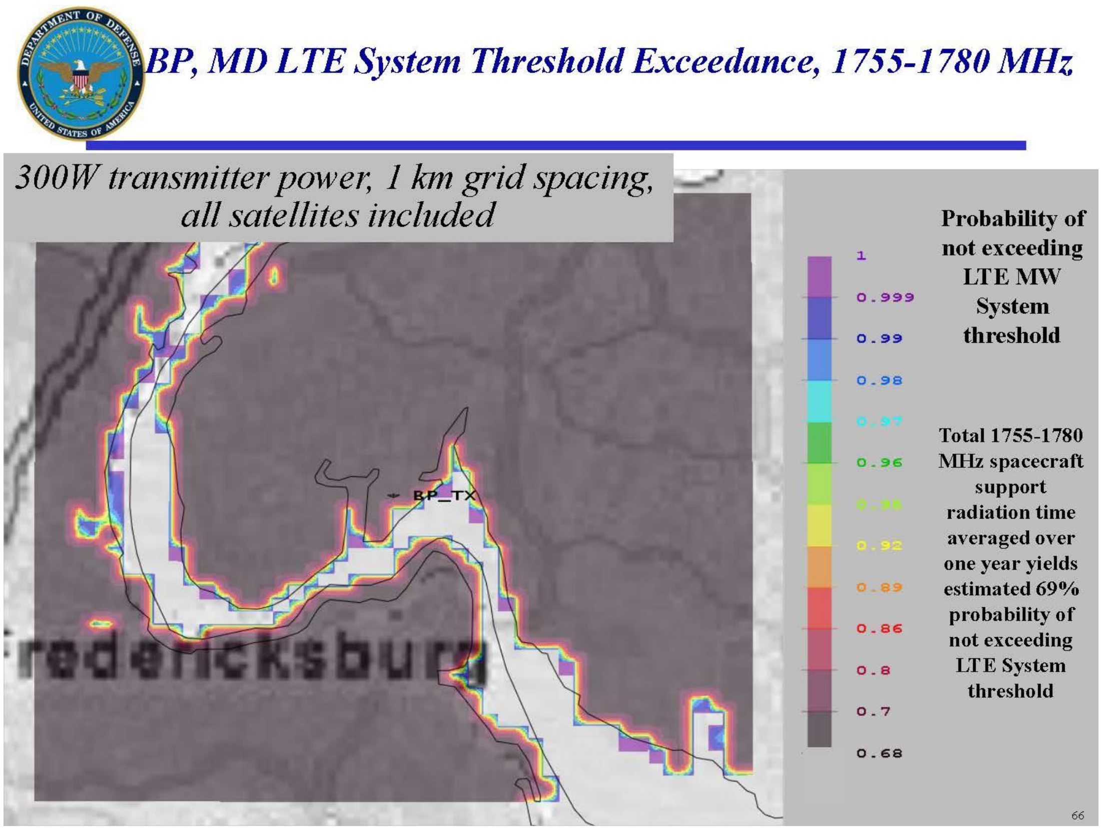
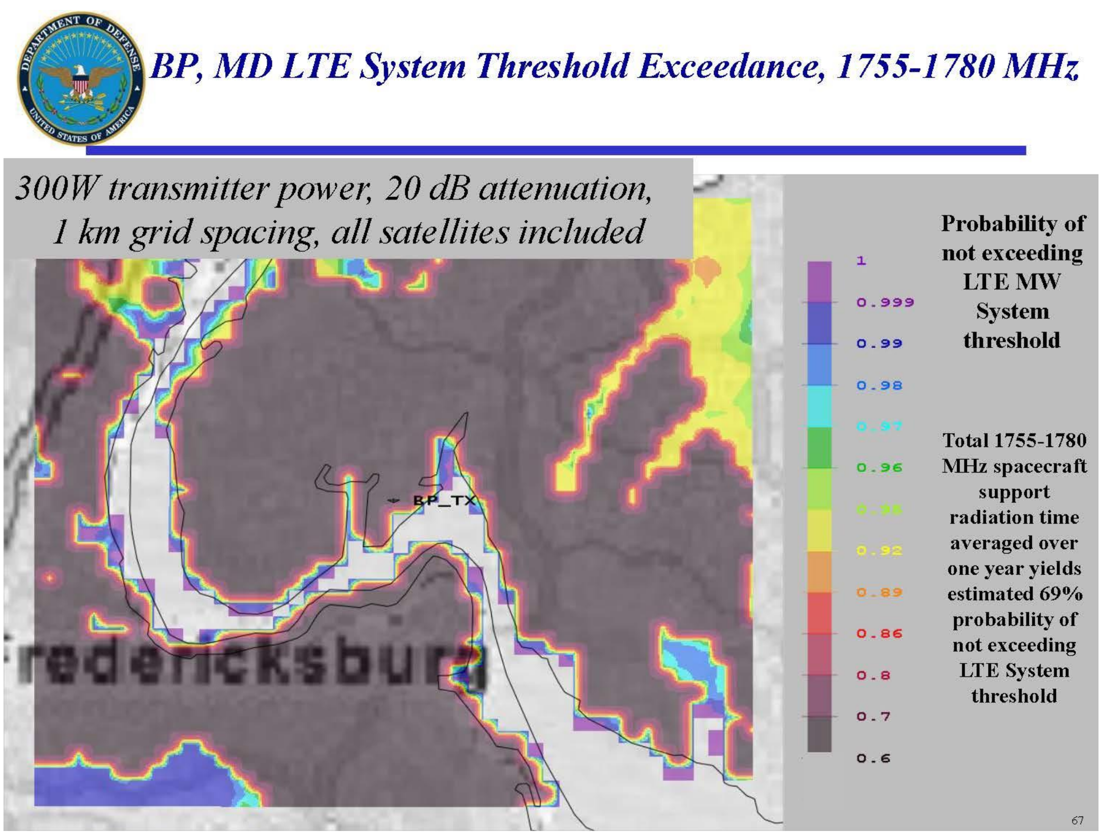
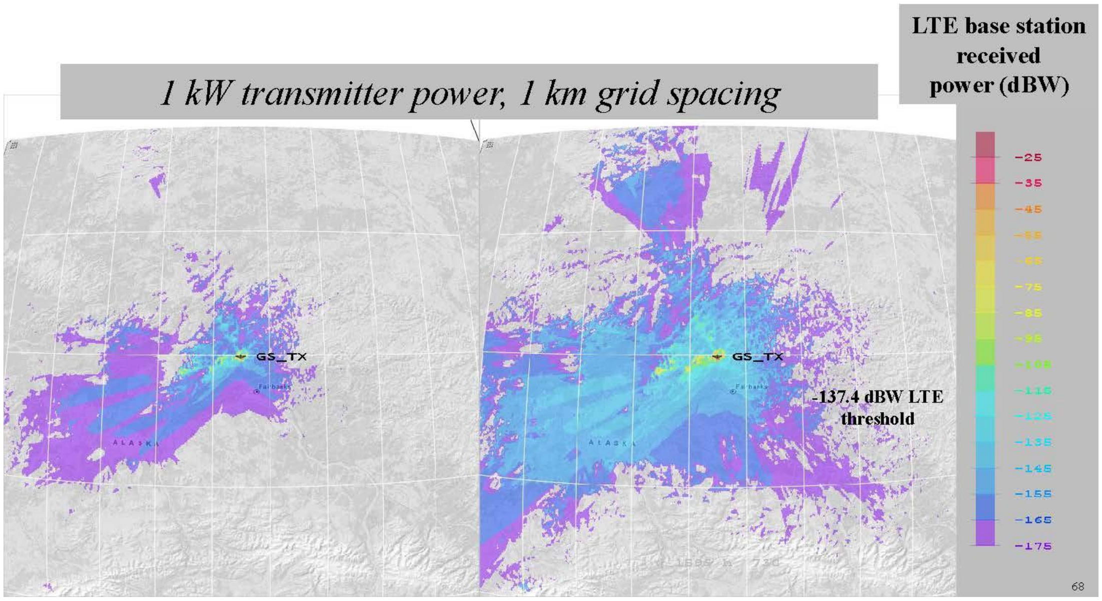

BP, MD LTE System Threshold Exceedance, 1755-1780 MHz
300W transmitter power, 20 dB attenuation
1 km grid spacing, one satellite not included
Probability of not exceeding LTE MW System threshold
1
0.999
0.99
0.98
0.96
0.92
0.89
0.86
0.8
Total 1755-1780 MHz spacecraft support radiation time averaged over one year yields estimated 92% probability of not exceeding LTE System threshold
BP_TX
Fredericksburg
65

2273


BP, MD LTE System Threshold Exceedance, 1755-1780 MHz
300W transmitter power, 1 km grid spacing, all satellites included
BP_TX
Fredericksburg
Probability of not exceeding LTE MW System threshold
1
0.999
0.99
0.98
0.96
0.92
0.89
0.86
0.8
0.7
0.68
Total 1755-1780 MHz spacecraft support radiation time averaged over one year yields estimated 69% probability of not exceeding LTE System threshold
66

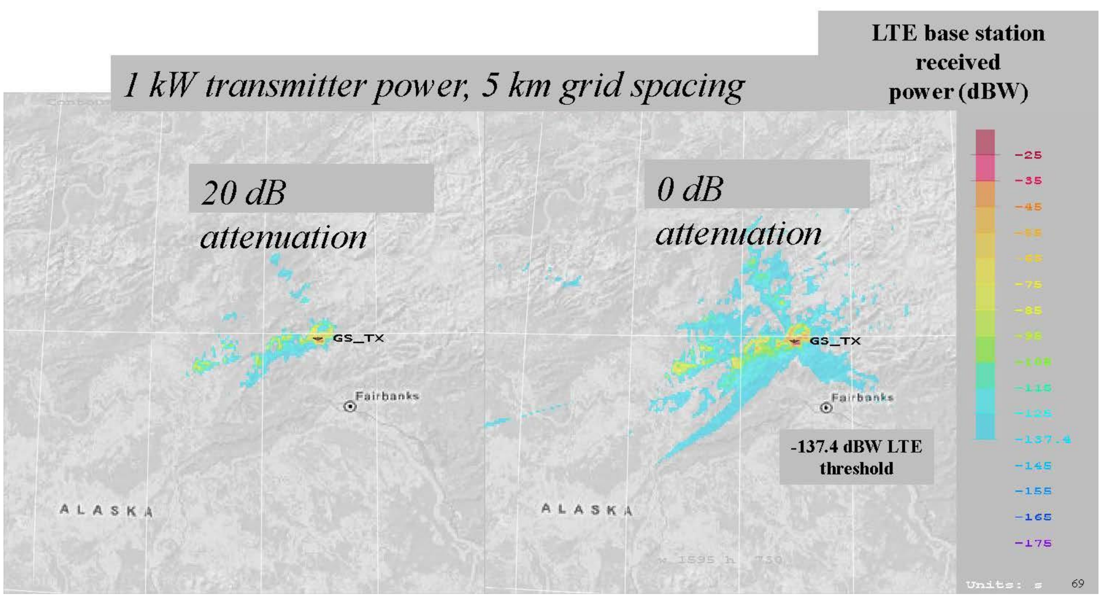

BP, MD LTE System Threshold Exceedance, 1755-1780 MHz
300W transmitter power, 20 dB attenuation, 1 km grid spacing, all satellites included
BP_TX
Fredericksburg
Probability of not exceeding LTE MW System threshold
1
0.999
0.99
0.98
0.96
0.92
0.89
0.86
0.8
0.7
0.6
Total 1755-1780 MHz spacecraft support radiation time averaged over one year yields estimated 69% probability of not exceeding LTE System threshold
67

FB, AK Power Contours

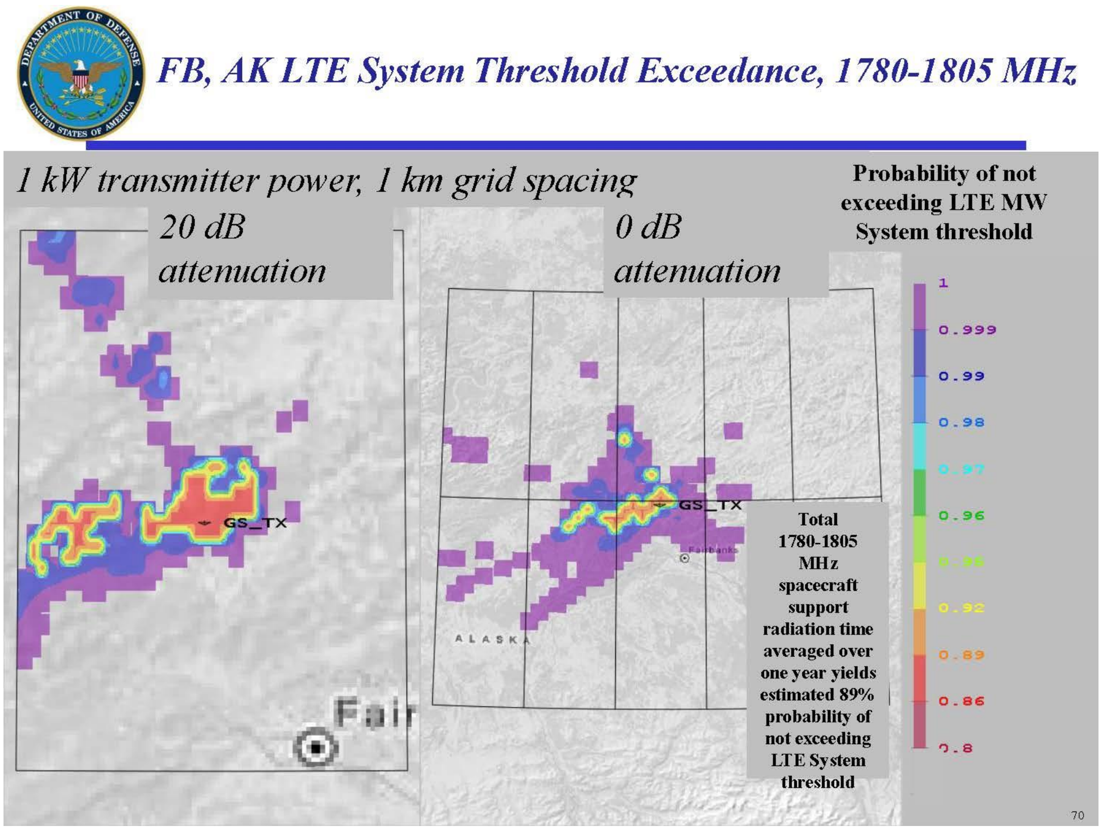


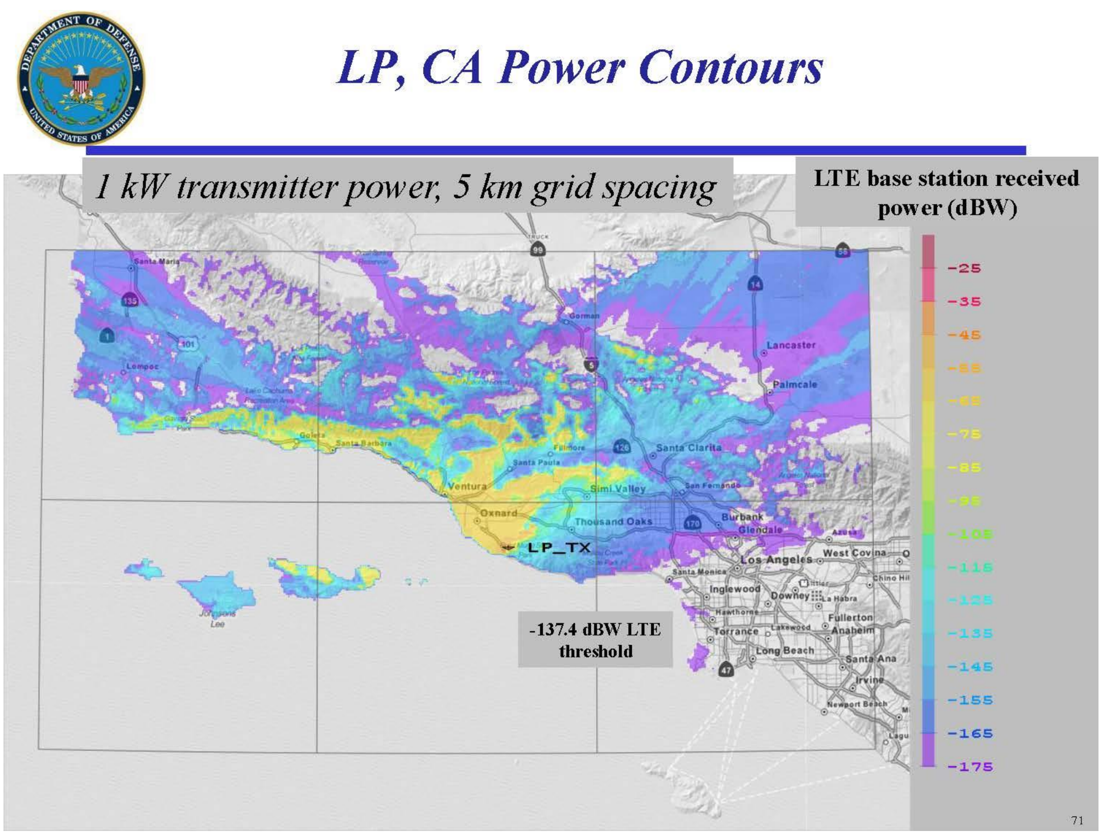
2276

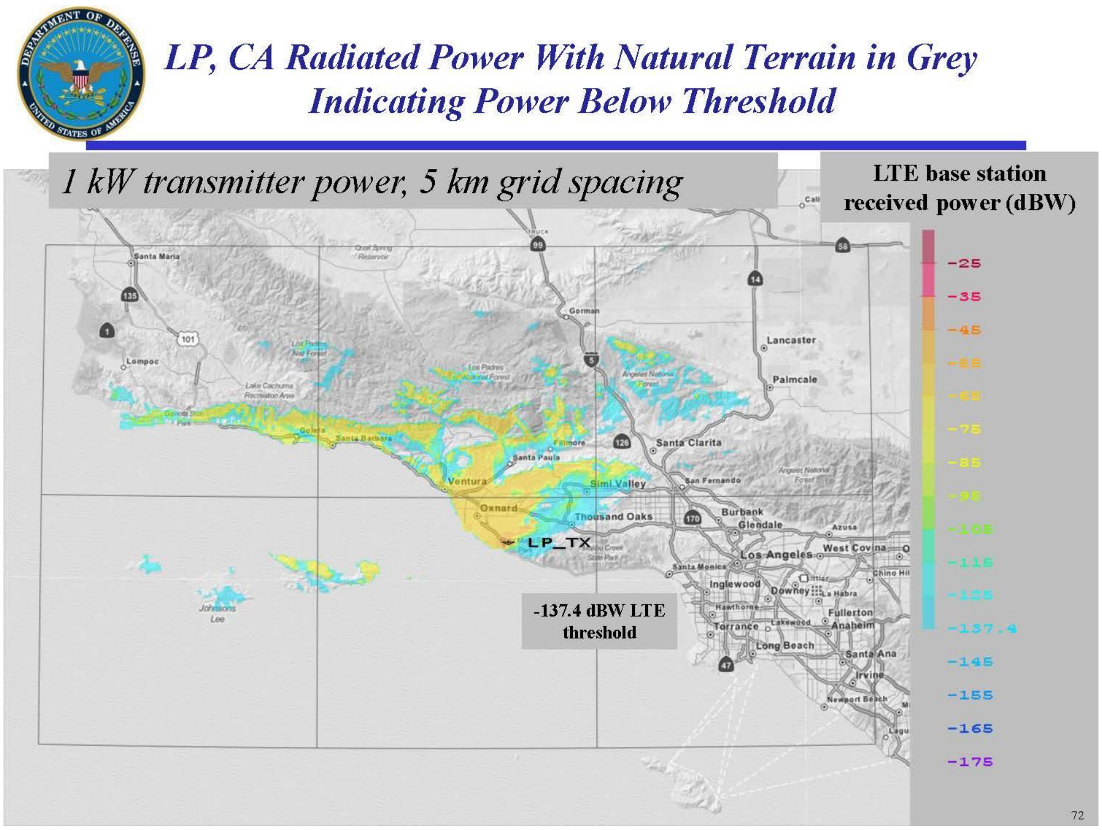
FB, AK Radiated Power With Natural Terrain in Grey Indicating Power Below Threshold

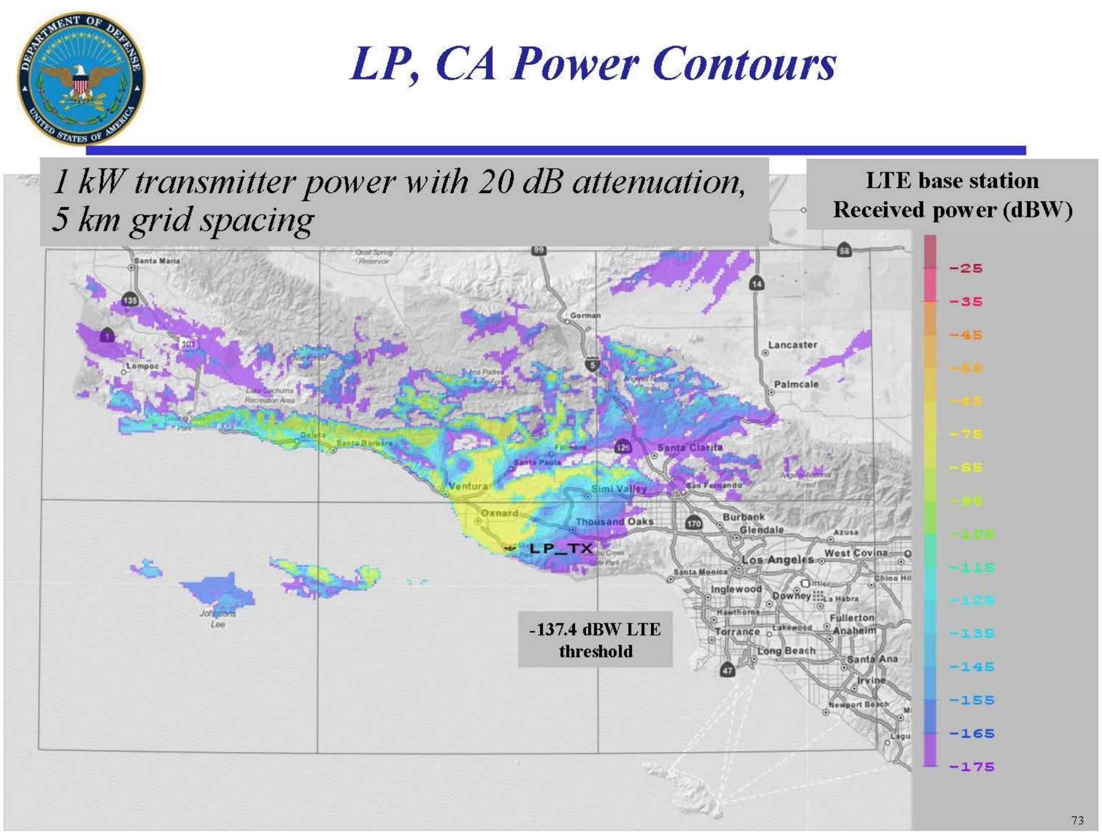


2277

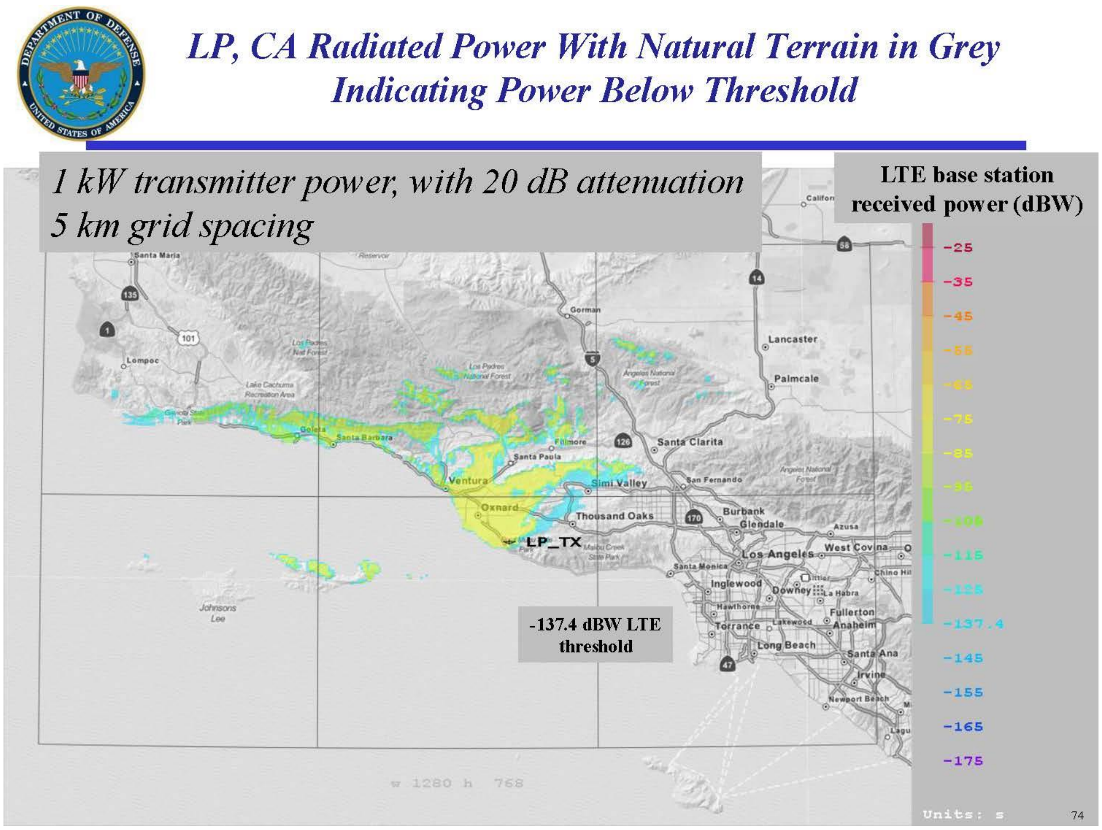

FB, AK LTE System Threshold Exceedance, 1780-1805 MHz
1 kW transmitter power, 1 km grid spacing
20 dB attenuation
0 dB attenuation
Probability of not exceeding LTE MW System threshold
1
0.999
0.99
0.98
0.97
0.96
0.92
0.89
0.86
0.8
GS_TX
GS_TX
ALASKA
Fairbanks
Fair
Total 1780-1805 MHz spacecraft support radiation time averaged over one year yields estimated 89% probability of not exceeding LTE System threshold
70


LP, CA Power Contours
1 kW transmitter power, 5 km grid spacing
LTE base station received power (dBW)
-25
-35
-45
-75
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
LP_TX
Santa Maria
Lompoc
Santa Barbara
Goleta
Ventura
Oxnard
Thousand Oaks
Simi Valley
Santa Clarita
Lancaster
Palmdale
Burbank
Glendale
Los Angeles
Santa Monica
Inglewood
Downey
West Covina
Torrance
Long Beach
Fullerton
Anaheim
Santa Ana
Irvine
-137.4 dBW LTE threshold
71


LP, CA Radiated Power With Natural Terrain in Grey
Indicating Power Below Threshold
1 kW transmitter power, 5 km grid spacing
LTE base station
received power (dBW)
-25
-35
-45
-55
-65
-75
-85
-95
-105
-115
-125
-137.4
-145
-155
-165
-175
LP_TX
-137.4 dBW LTE
threshold
72

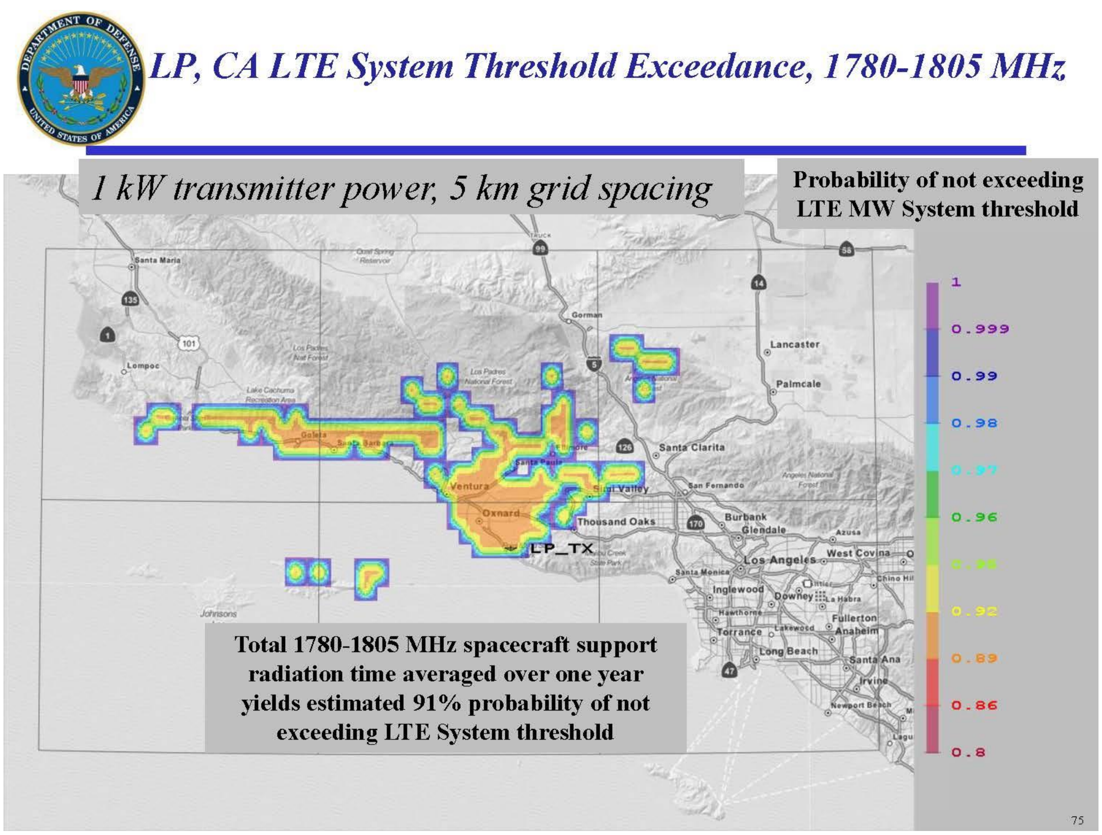

LP, CA Power Contours
1 kW transmitter power with 20 dB attenuation,
5 km grid spacing
LTE base station
Received power (dBW)
-25
-35
-45
-55
-65
-75
-85
-95
-105
-115
-125
-135
-145
-155
-165
-175
LP_TX
-137.4 dBW LTE
threshold
73

2282



LP, CA Radiated Power With Natural Terrain in Grey
Indicating Power Below Threshold
1 kW transmitter power, with 20 dB attenuation
5 km grid spacing
LTE base station
received power (dBW)
-25
-35
-45
-75
-85
-137.4
-145
-155
-165
-175
-137.4 dBW LTE
threshold
Santa Maria
Lompoc
Goleta
Santa Barbara
Ventura
Oxnard
LP_TX
Santa Paula
Fillmore
Simi Valley
Thousand Oaks
Santa Clarita
San Fernando
Burbank
Glendale
Los Angeles
West Covina
Santa Monica
Inglewood
Downey
La Habra
Fullerton
Anaheim
Hawthorne
Torrance
Lakewood
Long Beach
Santa Ana
Irvine
Newport Beach
Lancaster
Palmcale
Gorman
Azusa
Johnsons
Lee
w 1280 h 768
Units: s
74

2283

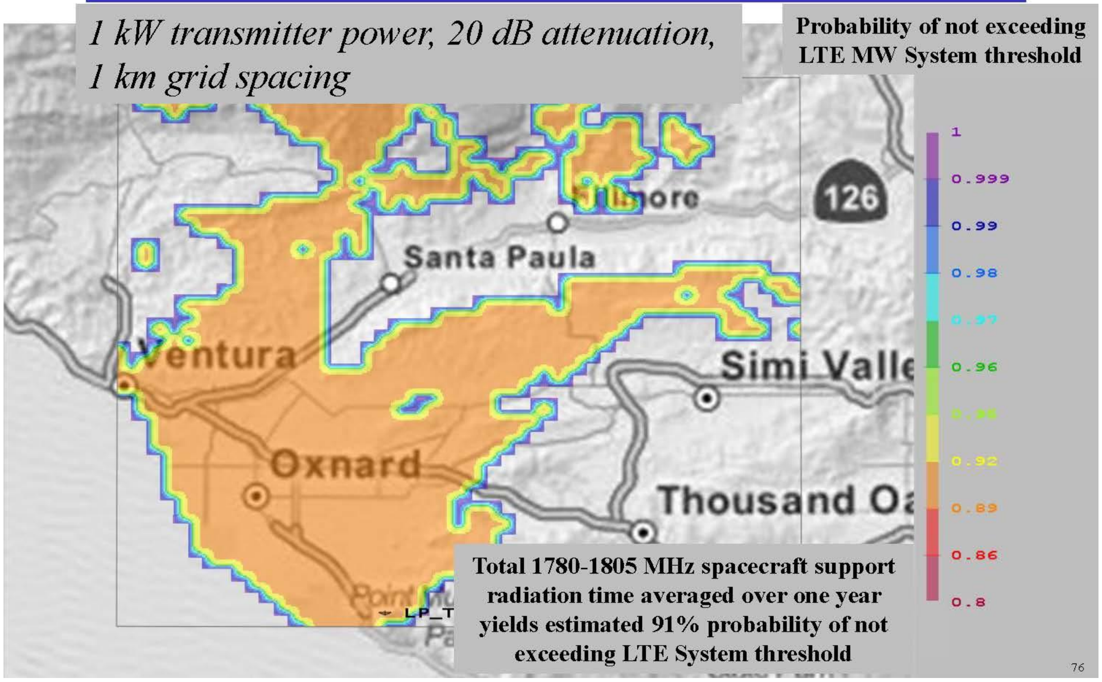


LP, CA LTE System Threshold Exceedance, 1780-1805 MHz
1 kW transmitter power, 5 km grid spacing
Probability of not exceeding
LTE MW System threshold
1
0.999
0.99
0.98
0.96
0.92
0.89
0.86
0.8
Total 1780-1805 MHz spacecraft support
radiation time averaged over one year
yields estimated 91% probability of not
exceeding LTE System threshold
Santa Maria
Lompoc
Ventura
Oxnard
LP_TX
Simi Valley
Thousand Oaks
Santa Clarita
San Fernando
Burbank
Glendale
Los Angeles
West Covina
Santa Monica
Inglewood
Downey
La Habra
Fullerton
Anaheim
Hawthorne
Torrance
Lakewood
Long Beach
Santa Ana
Irvine
Newport Beach
Lancaster
Palmcale
Gorman
Azusa
Johnsons
75

LP, CA LTE System Threshold Exceedance, 1780-1805 MHz

1 kW transmitter power, 20 dB attenuation, 1 km grid spacing

Probability of not exceeding LTE MW System threshold



2284 **Total 1780-1805 MHz spacecraft support radiation time averaged over one year yields estimated 91% probability of not exceeding LTE System threshold**

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Appendix B – Technical Rationale

- **The following topics are elaborated in this Appendix**
  - *ITM Parameters*
  - *Transmitter and Receiver Parameter Choices*
  - *RFI Overlap for Two Antennas Operating at a Site*
  - *Mathematical definition of Threshold Non-Exceedance Calculation*

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Irregular Terrain Model (ITM) - Input Parameter Value Choices

- **Electrical Parameters**

  1 - Polarization
  1-vertical
  0-horiziontal
  15 - Dielectric constant of ground
  4-poor ground
  15-average ground
  25-good ground
  81-fresh/sea water
  0.005 - Conductivity of ground
  0.001-poor ground
  0.005-average ground
  0.02-good ground
  0.01-fresh water
  5.00-sea water

- **Regional and Temporal Parameters**

  50 - # of Reliability/Time statistic
  50 - # of Confidence/Location statistic
  2 - Radio climate
  1-Equatorial
  2-Contental subtropical
  3-Maritime tropical
  4-Desert
  5-Contental Temperate
  6-Maritime temperate, over land
  7-Maritime temperate, over sea
  301 - Surface Refractivity
  280 - Desert (Sahara)
  301 - Continental Temperate
  320 - Continental Subtropical (Sudan)
  350 - Maritime Temperate, Over Sea
  360 - Equatorial (Congo)

2286 78

Transmitter and Receiver Parameter Choices

Transmitter Frequency (MHz)	1762
Transmitter Power (dBm)	60
Peak Antenna Gain (dBi)	*
Antenna Gain** @ Horizon (dBi) (3 deg elev)	16
EIRP @ Horizion (dBm)	*
Transmitter Antenna Height (m)	30
Receiver Antenna Height (m)	30
Receiver Antenna Down tilt (deg)	3
Receiver 3dB Beamwidth (el) (deg)	10
Receiver 3dB Beamwidth (az) (deg)	70
Receiver Antenna Gain at Horizon (dBi)	18.0
Receiver Ref Sensitivity (dBm)	-101.50
Receiver Interference @ 1 dB desense (dBm)	-107.37
Receiver Interference @ 3 dB desense (dBm)	-101.50
Receiver Sensitivity (1 dB desense, dBW)	-207.94
Receiver Sensitivity (3 dB desense, dBW)	-202.07

*Site Dependent
**Reference NTIA TM 13-489 Section 6.3.1.3 f (Ref 5)

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RFI Overlap for 2 Antennas

- **Radiation time for each antenna pointing angle was delivered as a sum of the time radiated in that direction by antenna A and the time radiated in that direction by antenna B**
  - *This causes some radiation time and thus some threshold exceedance time to be double-counted*
- **The overlapping threshold exceedance time can be described as:**

P(RFI Overlap) = P(ant A on AND ant A exceeding threshold AND ant B on AND ant B exceeding threshold)

- **This double-counted time was calculated (as shown on the next slide) and removed from the threshold exceedance times**

2288 80

RFI Overlap for 2 Antennas Calculation

- **Assuming independence between antenna A and antenna B,**

P(RFI Overlap) = P(ant A on)*P(ant A exceeds threshold | ant A on)* P(ant B on)*P(ant B exceeds threshold | ant B on)

- **Assuming the same radiation time for and received power distribution from the 2 antennas,**

P(ant A on) = P(ant B on) **and**

P(ant A exceeds threshold | ant A On) = P(ant B exceeds threshold | ant B On)

- *P(RFI Overlap)* $= P(\text{ant A on})^2 * P(\text{ant A exceeds threshold} \mid \text{ant A On})^2$
  $= [(\text{Radiate \%} / 2) * P(\text{ant A exceeds threshold} \mid \text{ant A On})]^2$
  $= (\text{Threshold Exceedance \%} / 2)^2$
- ***(Threshold Exceedance % / 2)***^{2} **is the correction factor that was used to remove double-counted threshold exceedance times from our calculations**

2289 81

Non-Exceedance Calculations Without Variance

- **Non-Exceedance Calculation**

$$P(NE) = \sum_{i=1}^{n}\sum_{j=1}^{m} P\left(NE\middle|[Az_i \cap El_j]\right) P(Az_i \cap El_j) + \left[1 - \sum_{i=1}^{n}\sum_{j=1}^{m} P(Az_i \cap El_j)\right]$$

where P(NE) = Probability of Non-Exceedance

(equation excludes correction factor discussed earlier)

- **Without Variance**

$P(NE \mid [Az_i \cap El_j])$ **is strictly 1 or 0 following the condition**

$$P\left(NE\middle|[Az_i \cap El_j]\right) = \begin{cases} 1 \; if \; MeanRxPwr < Threshold \\ 0 \; if \; MeanRxPwr \geq Threshold \end{cases}$$

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5 Full Participant Lists for WG 3

Colin	Alberts	Freedom Technologies
David	Alianti	Alion Science
John	Anton	Scitor supporting SAF/SP
Beau	Backus	Aerospace Corporation
Maj Jennifer	Beisel	
Derr	Bergenthal	Ratheon
Johnnie	Best	Navy
Dan	Bishop	
Vic	Blanco	PEO Space Systems
Michael	Brown	
Mark	Brushwood	AFSMO
Mike	Chartier	Intel
Matthew	Clark	Areospace Corp
Dick	Cote	Air Force/A3SO
Michael	Cotton	NITA
Brooks	Cressman	ITT Excelis
Mike	David	Overlook supporting 3AF/5P
Edward	Davison	NTIA
Arthur	Deleon	US Marine Corp
Richard	Desalvo	Army
Christine	Di Lapi	ITT Excelis
Tom	Dombrowsky	CSMAC Member Participant
Ed	Drocella	NITA
John	Duffy	Aerospace
Larry	Feast	DOD/DISA

Jason	Fortenberry	Army
Mel	Frerking	AT&T
George	Frescholtz	Air Force
Paul	Frew	RIM
Peter	Georgiou	FCC
Alexander	Gerdenitsch	Motorola Mobility
Mike	Goddard	invited guest from UK
Mary	Greczyn	
Jason	Green	Alion Science
Kathrine	Green	ITT Excelis
Rob	Haines	NTIA
Steven	Hobbs	AF/A5RS
Scott	Hoshar	Navy
Mark	Johnson	Navy
Col. Brian	Jordan	DOD CIO
John	Kennedy	FCC
Gitangli	Khushlani	
Tom	Kidd	Navy
Robert	Kindelberger	Navy
Scott	Kotler	NTIA
Robert	Kubik	Samsung
David	Manzi	Raytheon
Jeff	Marks	Alcatel-Lucent
Col Harold	Martin	Air Force
Albert	Mauzy	Navy
Ian	McClymonds	Alion Science
Lynn	McGrath	OSD DOD-CIO
Albert "Buzz"	Merrill	Aerospace
Fred	Moorefield	Air Force
Rich	Mosley	AT&T
James	Norton	General Dynamics
Janice	Obuchowski	CSMAC Member Participant
Glenn	Okui	Navy
James	O'Neill	Navy
Troy	Orwan	DOD CIO
Mark	Paolicelli	USMC
Gary	Patrick	NITA
Michael	Perz	Air Force
Clifton	Phillips	Navy
Carl	Povelites	AT&T
Kimberly	Purdon	USAF AFSMO
John	Quinlan	Whitehouse OMB
John	Radpour	AT&T
Rick	Reaser	CSMAC Member Liaison
Donald	Reese	Air Force
Raymond	Reyes	Army
Charles	Rush	CSMAC Member Liaison
Brian	Scarpelli	TIA
Steven	Schwartz	Army G-2
Wayne	Shaw	Association of Old Crows
Trent	Skidmore	National Coordination Office
Odell "Alden"	Smith	DISA/DSO
Jim	Snider	iSolon.org

Steven	Sparks	YPG
John	Suhy	HQDA Army EW
Thomas	Sullivan	ASRC/ARTS supporting NASA
Carol	Swan	Air Force
Neeti	Tandon	AT&T
Stuart	Timerman	DOD CIO
Gregory	Torba	Air Force
Howard	Watson	
Chris	Wieczorek	T-Mobile
Stephen	Wilkus	Alcatel-Lucent
Lori	Winn	DOD Joint Staff
Maurice	Winn	Alion Science
Susan	Woida	AF/A3SO
Lily	Zeleke	DOD CIO

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6 Abbreviations Used in This Report

3G	Third Generation
3GPP	3rd Generation Partnership Project
4G	Fourth Generation
ACIR	Adjacent Channel Interference Ratio
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
AFC	Area Frequency Coordinator
AFSCN	Air Force Satellite Control Network
AN, MD	Annapolis, Maryland
AWS	Advanced Wireless Services
BAFB	Buckley Air Force Base
BER	Bit Error Rate
BP, MD	Blossom Point Field Site, Maryland
BS	Base Station
BW	Bandwidth
C/N	Carrier to Noise Ratio
C2	Command and Control
CAPEG	Cape GA, CCAFB, Florida
CDF	Cumulative Distribution Function
CONUS	Continental United States
CP, CA	Camp Parks Communications Annex, Pleasanton, CA
CSEA	Commercial Spectrum Enhancement Act
CSMAC	Commerce Spectrum Management Advisory Committee
CTS	Colorado Tracking Station, Schriever AFB, Colorado
d	Mobile Station Antenna effective height. (m) Link distance. (km)
dB	Decibel
dBi	Decibel Isotropic
dBm	Power ratio in decibels reference to one milliwatt
dBW	Power ratio in decibels reference to one watt
DCI	Downlink Control Information
DE	Directed Energy
DGS	Diego Garcia Tracking Station, British Indian Ocean Territory, Diego Garcia
DL	Downlink, for mobile devices this is link from the base station to the mobile device, for satellite communications this is the satellite to earth station link
DoD	Department of Defense
EA	Electronic Attack
EIRP	Equivalent Isotropic Radiated Power
EM	Electromagnetic Energy

EMS	Electromagnetic Spectrum
eNodeB /eNB	Evolved Node B, also referred to as base station
E-UTRA	Evolved Universal Terrestrial Radio Access
EVCF	Eastern Vehicle Checkout Facility, Cape Canaveral AFS, Florida (Launch support only)
EW	Electronic Warfare
f	Frequency of Transmission (MHz)
FAA	Federal Aviation Administration
FACSFAC	Fleet Area Coordination and Surveillance Facility
FB, AK	Fairbanks (NOAA), Alaska
FB, NC	Ft. Bragg, NC
FB, VA	Fort Belvoir, Virginia
FCC	Federal Communications Commission
FDD	Frequency Duplex Division
FDR	Frequency dependent rejection (dB)
FER	Frame Erasure Ratio
FH, TX	Ft. Hood, TX
FSS	Frequency Selective Scheduling
GHz	Gigahertz
GNS	Guam Tracking Station, Andersen AFB, Guam
G_R	Antenna gain of the BS receiver in the direction of the SATOPS uplink station (dBi)
GSO	Geostationary Satellite Orbit
GTS	Guam Tracking Station, Andersen AFB, Guam
H_B	Base Station Antenna effective height. (m)
HB, CA	Huntington Beach , CA
Hi	Hawaii
H_m	Mobile station Antenna height correction factor as described in the Hata Model for Urban Areas
HTS	Hawaii Tracking Station, Kaena Point, Oahu, Hawaii
Hz	Hertz
I	Received interference power at the output of the BS receiver antenna (dBm)
I_{AGG}	Aggregate interference to the BS system receiver from the SATOPS transmitters (dBm)
I_j	Interference power level at the input of the base station receiver from the j^{th} SATOP transmitter (Watts)
IRAC	Interdepartment Radio Advisory Committee
ISD	Inter Sector Distance, distance between two base station sites
ISR	Intelligence, Reconnaissance and Surveillance
ITU	International Telecommunications Union
JB, WA	Joint Base Lewis-McChord, WA
KAFB	Kirtland AFB, New Mexico
kHz	Kilohertz
KW, FL	JIATF-S, Key West, FL
L	Median path loss. (dB)
LFE	Large Force Employment Exercises
LIMFAC	Limiting Factors
L_L	Building and non-specific terrain losses (dB)
L_P	Propagation loss between BS and SATOPS uplink station (dB)
LP, CA	Laguna Peak, California (Navy)
L_R	BS insertion loss (dB)
LTE	Long Term Evolution
m	meter
MHz	Megahertz
MILDEPS	Military Department
MO, CA	Monterey, California

MOU	Memorandum of Understanding
MSL	Mean Sea Level
N	Number of SATOPS transmitters
	Noise Power
NASA	National Aeronautics and Space Administration
NDA	Non-Disclosure Agreement
NGSO	Non-Geostationary Satellite Orbit
NHS	New Hampshire Tracking Station, New Boston AFS, New Hampshire
NIB	Non-Interference Basis
NORAD	North American Aerospace Defense Command
NTIA	National Telecommunications and Information Administration
OOB	Out-of-band
P	Transmit power
PDCCH	Physical Downlink Control Channel
PDF	Probability Distribution Function
PH, ME	Prospect Harbor, Maine (Navy)
PNT	Position, Navigation and Timing
PR	Puerto Rico
PR, MD	Patuxent River NAS, MD
PRB	Physical Resource Block
$P_{REFSENS}$	Power at reference sensitivity
QN, VA	Quantico, Virginia
RCC-FMG	Range Commander Council Frequency Management Group
RCIED	Radio Controlled Improvised Explosive Device
RDT&E	Research, Development, Test and Evaluation
RF	Radio Frequency
RFI	Radio Frequency Interference
RLC	Radio Link Control
Rx	Receive
SA, TX	San Antonio Texas
SAC, CA	Sacramento, CA
SATOPS	Satellite Operations
SDS	Spectrum Dependent System(s)
SEM	Spectral Emission Mask
SF	Scale factor
SGLS	Space Ground Link Subsystem
SGP	Series of Satellite Orbital models (SGP, SGP4, SDP4, SGP8 and SDP8)
SME	Subject Matter Experts
SMO	Spectrum Management Office(s)
SNS	Space Network System
SRF	Spectrum Relocation Fund
TCS	Oakhanger Telemetry and Command Station, Borden, Hampshire, England
TT&C	Telemetry Tracking and Command
TTP	Tactics, Techniques and Procedures
TTS	Thule Tracking Station, Thule Air Base, Greenland
Tx	Transmit
U.S.	United States
UE	User Equipment
UL	Uplink, for mobile devices this is link from the mobile device to the base station, for satellite communications this is the earth station to satellite link
UL-MIMO	Uplink Multiple Input Multiple Output
UMTS	Universal Mobile Telecommunications System
US&P	United States and Possessions
VTS	Vandenberg Tracking Station, Vandenberg AFB, California
WG 1	CSMAC Working Group 1
WG 3	CSMAC Working Group 3

x	Frequency in MHz
Δf_{OOB}	Offset frequency for out-of-band emissions